Newsletter Environmental Technology
(November 2011)

Erik Smet & Stefaan Deboosere, Trevi nv
esmet@trevi-env.com *www.trevi-env.com*

INCREASING THE PERFORMANCE OF BIOLOGICAL WASTE GAS TREATMENT SYSTEMS BY COMBINING THEM WITH NON-BIOLOGICAL TECHNIQUES

Biological waste gas treatment systems or biotechniques are widely used in the industrial world, and this mainly for the abatement of odorous and VOC-containing waste gases. In this report, it is shown that the performance and the application field for these biotechniques can be strongly increased by combining them with non-biological waste gas treatment systems in an intelligent way.

► Introduction

Biological waste gas treatment consists of a mass transfer process of the pollutant from the gas phase towards the water phase, followed by a microbiological oxidation process of the pollutant in a biofilm (biofilter or biotrickling filter) or in a microbial suspension (bioscrubber). Actually, there are two prerequisites for a biotechnique to be successful in a specific situation: the pollutant should be biodegradable and the pollutant should at least be slightly water soluble.

With regard to the water solubility, it is often stated that biotechniques can be used for pollutants having a dimensionless Henry constant below a value of 1 to 10. This would mean that biofiltration of alkanes and alkenes is very difficult or impossible.

With regard to the biodegradability, it has to be mentioned that some compounds can only be degraded under anaerobic conditions (e.g. perchloroethylene) or using cometabolic microbiological processes (e.g. trichloroethylene). Next to that, biodegradation of some compounds requires long start-up periods if no inoculation with specific micro-organisms is applied.

Finally, it is important to note that strong fluctuations in contaminant concentrations in a waste gas often adversely influence the effectiveness of bioreactors for waste gas treatment.

In several situations, one or more of these three aspects hinders the application of biotechniques for pollution control. Based upon the experience of TREVI (*www.trevi-env.com*), however, some of these disadvantages of biotechniques can be neutralised when these systems are combined with non-biological waste gas treatment systems in an intelligent way..

► Selective removal of a highly concentrated pollutant

Several odorous waste gases contain one specific compound in a high or very high concentration (10 to 1000 mg/m^3), while the remaining odorants are present in very low (1 to 1000 µg/m^3) concentrations. Well-known is for instance the occurrence of high ammonia (NH_3) concentrations in composting waste gases, high hydrogen sulfide (H_2S) concentrations in the noncondensable waste gases of a rendering plant and high hydrogen chloride (HCl) concentrations in the waste gases originating from hydrolysis processes.

Although H_2S and NH_3 can easily be degraded in a bio(trickling) filter, their presence in high concentrations will have a strong impact on the dimensioning of the bioreactor. The presence of HCl in an odorous waste gas will, on the other hand, result in a strong acidification and desactivation of the bioreactor.

In some cases, it is worth to evaluate the combination of two biotechniques. This is for instance the case for waste gases loaded with both H_2S and volatile organic sulfur compounds. Two bioreactors are required in order to separate the acidophilic H_2S-oxidising micro-organisms and the acidophobic degraders of the organic sulfur compounds. A combination of a lava filter or a trickling filter without pH-control and a trickling filter with pH-control can be a valuable option in this case.

Most often, however, it is required to remove the highly concentrated pollutant in a chemical scrubber, while the remaining pollutants can be degraded in the subsequent bioreactor. In this case, an acid scrubber is used to remove ammonia, while a caustic scrubber is required for H_2S- or HCl-removal. For the removal of high concentrations of volatile organic compounds, a caustic oxidative scrubber is most often used. See the website of BETE (*www.betescrubbers.com*) for more info about chemical scrubbing.

► Peakshaving

In some waste gases, strong fluctuations in contaminant concentration (up to a factor 10 to 100) can be observed as a function of time. A well-known example is the emission profile of solvents in paint spray booths. Dimensioning of the bioreactor based upon these peak concentrations would yield very oversized and expensive installations. In this situation, the use of a peakshaver in front of the biotechnique can have a pronounced positive effect. A peakshaver consists of a reactor filled with a selective adsorbent. During the peak emission, the adsorbent will temporarily adsorb the pollutant, while a desorption will occur from the peakshaver towards the biotechnique afterwards.

Figure 1 illustrates the impact of such a peakshaver on the emission profile (case: toluene at a spray booth).

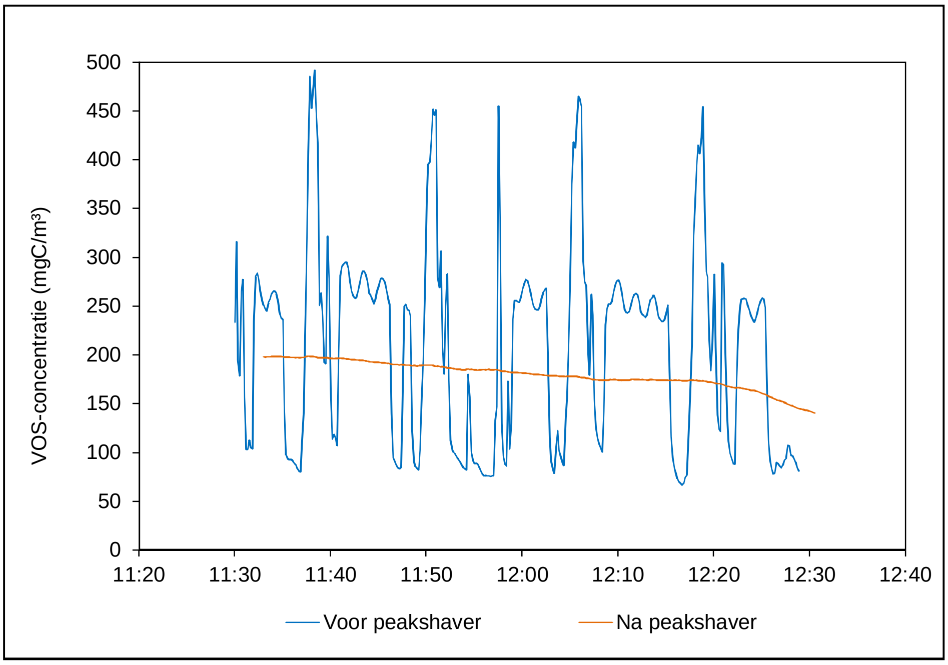

Figure 1. Effect of a peakshaver in front of a biological waste gas treatment unit (case: toluene at a spray booth)

The biological filter that is placed after the peakshaver will no longer be affected by the strong fluctuations in contaminant concentrations. Next to that, no ‘consumption’ of adsorbent will occur in the peakshaver since the contaminant will be desorbed once the peak has gone. It is clear that the waste gas should be free of dust in order to prevent blockage of the peakshaver.

► Partial oxidation

For some pollutants, chemical oxidation can yield partial oxidation products with strongly increased water solubility and/or biodegradability. Mainly new advanced oxidation processes (AOP) such as e.g. photo-oxidation, ozonisation and non-thermal-plasma (NTP) can be used for this. The energy consumption of these chemical techniques is most often too high in order to obtain a complete mineralisation of the pollutant. However, a moderate treatment will yield partial oxidation products that can easily be treated in a subsequent biotechnique.

The injection of ozone in the waste gas towards the biotechnique is probably the most simple way of obtaining this partial oxidation. This requires, however, that ozonisation kinetics for the pollutant and gas contact times between the pollutant and ozone are high enough. For styrene, for instance, the injection of small amounts of ozone in the waste gas will yield easily biodegradable oxidation products with a Henry constant that is 100 (benzaldehyde) to 1000 (formaldehyde) times lower than the value for styrene (see Figure 2). In practice, we observed that the elimination capacity of a biofilter was doubled upon the injection of ozone in the waste gas. Similar results can be obtained for e.g. alkenes, acrylates, terpenes, furanes and amines.

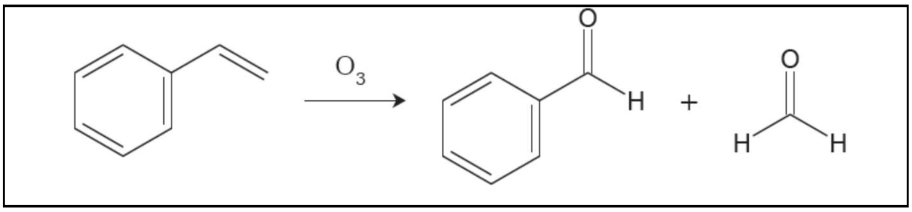

Figure 2. Partial oxidation of styrene using ozone

In the international literature, some reports mention that this synergetic effect of ozone and biofiltration also stands for compounds which are not susceptible towards ozone oxidation (e.g. chlorobenzene). The explanation for this would not be the partial chemical oxidation of the pollutant, but the direct stimulation of the biological activity in the bioreactor and the improved pollutant mass transfer due to the reduced extracellular polymers content in the biofilm.

Similar synergetic effects can be obtained upon pretreatment of the waste gas with UV-C light (most often 185 nm), e.g. for toluene and xylene. This pretreatment of the waste gas also yields several partial oxidation products which are easily biodegradable, as e.g. aldehydes. Also a moderate NTP-treatment of toluene loaded waste gas yields easily biodegradable and hydrophilic compounds, as e.g. alcohols, aldehydes and organic acids.

The last decade, much research has been done worldwide with regard to the removal of chlorinated VOCs, such as trichloroethylene and dichloroethane. Due to the low energy needed to break the chemical bond in C-Cl, chemical processes as photolysis and O_3/UV can be used for this application. Most researchers, however, mention the high energy requirement in order to obtain complete mineralization and the formation of noxious photostable by-products. According to our experience, the combination of a “light” chemical pretreatment and a biological post treatment can be a cheap and efficient way to remove the chlorinated VOCs and to obtain complete mineralisation. Pilot tests, however, are absolutely necessary in this case in order to confirm the applicability and to define the dimensioning.

► Conclusion

For numerous waste gases, the application of bioreactors is not considered based upon e.g. the presence of a toxic (concentration of) pollutant in the waste gas, strong fluctuations in pollutant concentrations or a low biodegradability and/or a very low water solubility of the compounds. In this article, it was shown that the application field of biotechiques can strongly be increased by combining them with non-biological waste gas treatment systems as e.g. chemical scrubbing, ozone dosing and peakshaving.

Trevi nv
Dulle-Grietlaan 17/1
9050 Gentbrugge
Belgium

T +32 9 220 05 77
F +32 9 222 88 89
E info@trevi-env.com
S www.trevi-env.com

ISO 14001
ISO 9001
VCA
BE 0447.717.158